

# The sun

*The following questions were answered by astronomer Dr. Cathy Imhoff of the Space Telescope Science Institute.*

**How large is the sun?** Pretty big! Its diameter is about 860,000 miles. You could line up 109 Earths along the diameter of the sun!

**How heavy is the sun?** Now that's a heavy question! The sun weighs 4.4 followed by 30 zeros pounds! By comparison, the earth weighs 1.3 followed by 25 zeros pounds. So the sun's weight equals 340,000 Earths!

**How big is the core of the sun?** The sun is about 860,000 miles in diameter. (That would take our car 1.5 years to drive across!) What we call the core of the sun is the inner part where the nuclear energy is released. This is the source of the energy that we see as light from the sun. The core is about one-fourth the size of the sun, or about 200,000 miles across. That is still pretty big! Earth is only about 8,000 miles across.

**How did the sun form?** We believe that the sun formed from a big cloud of gas and dust. The cloud was dark and cold, and its gravity caused it to fall together. The gas that collected at the center got hot from all the other gas falling on it. When nearly all the gas and dust had fallen together, the center became very hot and very dense our sun. Some of the leftover gas and dust going in orbit around this baby sun became the planets.

**How does the sun get its gases?** Most of what the universe is made of is gas mostly hydrogen gas. When the sun formed, it formed from a cloud of gas. However its gravity holds it together very strongly, making it hot and dense.

**How far away are we from the sun?** Earth (and we) are about 93,000,000 miles from the sun. To give you an idea about how far that is, suppose we could build a highway and drive a car to the sun. Let's drive 65 miles per hour. It would take over 160 YEARS to get there!

**How hot is the sun?** The surface of the sun is about 10,000 degrees Fahrenheit (5,770 degrees Kelvin). That may seem mighty hot, but it is even hotter deeper inside the sun.

**What is the temperature of the sun's core?** The sun's core is extremely hot about 27 million degrees Fahrenheit (15 million degrees Kelvin). That is because of the tremendous pressure of the weight of the sun pressing down on the core equal to 333,000 Earths. In pounds, that is 9 followed by 29 zeros!

**How do you measure how hot the sun is if you can't get that close to measure?** One way is to study the sun's spectrum that is, break up its light with a prism. A rainbow is a spectrum created when sunlight goes through raindrops, which act as little prisms. If we do this with a special device called a spectrograph, we can see that there are thin dark lines throughout the sun's spectrum.

Scientists have examined the different elements on earth, so we are able to figure out what kind of gas, say hydrogen, gives rise to which dark lines. It turns out that every element has a unique set of dark lines, like fingerprints. We can use them to figure out what the sun and stars are made of. They also show us how hot the gases are.

Another way is to look at sunlight and measure how much light is in the blue part of the spectrum, in the yellow, in the red. The hotter something is, the more light it gives off in the blue compared to the red. All these methods show us that the sun's surface is about 10,000 degrees Fahrenheit!

**How close can you get to the sun without burning?** Not very close! Have you ever gotten a sunburn? That's right here on earth with the atmosphere to protect you. In space, you would have no protection from the sun's ultraviolet light (on earth the ozone layer protects us). If you could go into space without a spacesuit, you would get burned badly by the sun.

**How close have people gotten to the sun?** So far people have circled Earth in spacecraft and the shuttle, but that is only a few hundred miles up. Years ago NASA astronauts went to the moon, which is about 250,000 miles away. But that is it. We have not yet visited any other planets or gotten close to the sun. For comparison, the sun is 93,000,000 miles away much, much further than the moon.

**How do scientists determine the layers of the sun?** The outer layers, which we can see, are the corona, the chromosphere, and the photosphere. We can use the techniques I described above to measure their temperatures.

Inside the sun there are also layers, but we can't see them. We know about them only from detailed mathematical models of the interior of the sun. We test these models to see if they accurately represent how the sun looks and behaves. They give us our best "guess" of what is going on inside the sun.

**What is the next closest star to Earth besides our sun?** That would be the double star Alpha Centauri. It is the brightest star in the constellation Centaurus, which unfortunately we can't see from the U.S. since it is in the southern sky.

Alpha Centauri consists of two stars in orbit around each other. They are nearly twins, and are also very similar to our sun. It takes 80 years for the two stars to orbit each other.

There is a third star, called Proxima Centauri, which may be in orbit around the other two stars. It is a dim, cool star, but happens to lie a little closer to us than the other two. Thus the name Proxima.

**If there is no oxygen in outer space, how does the sun burn? Don't things need oxygen in order to burn?** There is no oxygen in space. Then how can the sun be burning? The answer to that is that the sun isn't burning the way we usually think of things. The energy and light from the sun come from nuclear reactions deep inside the sun that occur at incredibly high temperatures millions of degrees!

That energy keeps the entire sun hot, although at the surface it is ONLY about 10,000 degrees Fahrenheit. Anything that hot will glow and give off light, and that is why the sun is bright and looks like it is on fire.

**Why is the sun orange in the morning and bright white in the afternoon?** If you look at the sun when it is first rising in the morning or setting in the evening, it is passing through more of the earth's atmosphere. The air scatters light, but it scatters blue and green light the most. Why is the sky blue? Because that is all the blue sunlight that the air has scattered!

In the middle of the day, the sun seems white because not that much blue light is scattered. But in the morning and evening, most of the blue and green light are scattered. If you take blue and green away from white, you get orange and red. You may have noticed that the sun seems dimmer in the

morning and evening than in the middle of the day. That is correct, because some of the light has been scattered away.

**Why doesn't the sun look like the other stars?** Actually the sun is very much like the other stars. But it is much closer. The nearest star other than the sun, Alpha Centauri, is over 200,000 times farther away! If we put the sun at that distance, it would look just like Alpha Centauri!

**Is Earth moving away from the sun?** No, I don't think Earth is moving away from the sun. It has been in orbit at about the same distance for a long, long time or life would not have survived here.

**What is going to happen to the sun?** We think that in about 4.5 billion years, the sun will run out of hydrogen in its center. The source of the sun's energy (and most other stars) is nuclear reactions that change hydrogen into helium. Then the center of the star will collapse, but only part way. The outer part will be blown out like a balloon, and our sun will become a "red giant." The surface will look red and will be a little cooler than it is now, but it will grow large it will probably expand all the way out to the orbit of Mercury.

At this point, the sun can use nuclear reactions of the helium that it made earlier, and convert it to carbon. When it runs out of nuclear reactions that can occur in the center, the sun will not be able to make much energy. So it will collapse, but we think that it will become a "white dwarf" a small but hot star that would be only about the size of the earth! Then the white dwarf will slowly give off its heat, becoming dimmer and cooler, until eventually all that would be left is a star cinder. All this would take many millions of years.

When the sun becomes a red giant, it will be a whole lot hotter in the solar system! It will probably vaporize Mercury, and Venus and Earth would be charred. The outer planets would probably have their clouds burned away. We think that only really massive, big stars can become black holes. When they get old, they will go through similar (although more complex) changes. But when a very massive star collapses, its gravity can be so great that it will compress its mass to a point a black hole.

A black hole still has the same gravity as the star that made it. So it will affect only what is nearby, just like the star, except that if you get too close, zoom down the hole! But if a star had planets, they could probably continue in their orbits if nothing else changed. And no, the whole galaxy wouldn't be sucked up. We think that there may be big black holes in the center of many galaxies, but they are still not big enough to do that.

**If the sun is so hot, why doesn't it just burn up?** A star can exist because the heat it generates inside, due to nuclear reactions, pushes outward, but this is balanced by its gravity, which pulls inward.

For a star like our sun, these forces are in balance. We think that a really big star, once it uses up all its nuclear fuel, will collapse and nothing can stop it. Gravity will take over, and all the matter in the star will collapse to a point. Near that point, the gravity is so strong that even light can't escape. That is why it is a BLACK hole no light. Although this may sound pretty crazy, we think we have found black holes at the centers of some galaxies!

The sun doesn't burn up because its source of power is nuclear energy. In the center of the star, there are tremendous temperatures (12 million degrees!) and pressures that help produce nuclear fusion. Hydrogen is being converted into helium, and energy is given off. The sun has a LOT of hydrogen.

We know that the sun is about 4.5 billion years old, and we compute that it has about another five billion years to go before it runs out of hydrogen. So it will run out of fuel some day fortunately for us it won't be for a LOOOONG time.

**Why doesn't the sun drift off into another galaxy?** Our galaxy is composed of billions of stars. They "hang together" because of their gravity. So our sun is kept in its path in our galaxy by the gravity of all those other stars.

Have you seen a picture of a spiral galaxy? We believe that is what the Milky Way looks like. The sun is in an orbit in our galaxy. It is moving (the other stars are too) in a huge circle around the center of the galaxy. It takes about 200 million years for it to go around once!

**If the sun blows up, what effect will it have on the other planets?** First, let me assure you that the sun is not going to blow up any time soon! In about five billion years, the sun will run out of energy. But that is nothing for us to worry about. If the sun became a supernova, the explosion would probably destroy the planets.

Fortunately the sun is too small to become a supernova. If the sun were to run out of energy, it would quit putting out its light. Then it would get very cold and dark here! The sun is, one way or another, the source of energy for all of us.

**Are sunspots like magnets?** Sunspots are formed because of loops of magnetic fields in the sun. The loop, which has a north pole and a south pole like a magnet, somehow keeps that part of the sun's surface from being quite as hot as the rest, making it look dark compared to the rest of the sun. We are still not sure where the loops of magnetic field come from, except that they come up from inside the sun.

**Can you tell me how deep are sunspots?** I think they are fairly shallow (not as deep as they are wide). Somehow the strong magnetic fields in the sunspots work to reduce the amount of light coming from inside the sun through the spot, so it is cooler than the surrounding surface of the sun and looks darker. But it's still pretty hot. The temperature is about 8,000 degrees Fahrenheit in the spot, and about 10,000 degrees at the surrounding surface of the sun!

**Does the amount of fusion in the core of the sun affect temperature?** The amount of nuclear fusion that happens inside the sun is the source of all the energy we get from the sun. It is also the source, one way or another, of nearly all the energy we use on the earth. So if the amount of fusion decreased, then the energy from the sun would go down. Probably the surface of the sun would be cooler. And it would DEFINITELY get cooler on the earth.

Fortunately the sun has been undergoing nuclear fusion at a pretty constant rate for billions of years, and we believe that it will continue for several more billions of years.

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